PROGRESS REPORT

FOR

NOVEMBER 1965

RESEARCH AND DEVELOPMENT FOR FABRICATING A TITANIUM GORE SEGMENT

NAS 8-20534

Prepared for

George C. Marshall Space Flight Center

by

The Boeing Company
Aerospace Group
Space Division
Launch Systems Branch

SUMMARY

The starting date for Phase II was October 25, 1965. Since that date, significant progress has been made; in fact, it appears at this time that the program is approximately two weeks ahead of schedule. The Screed tool is complete; the Vacu-form tool is about 85 percent complete; the Manufacturing Plan, the miscellaneous tooling, and the redesign of the gore segment are approaching completion.

Phase I of the contract was devoted to process development and tool design. Specifications for the Vacu-form tool were written from the conclusions of the process development effort. The tool, designed to these specifications, increased in size from the originally proposed 11 by 16-foot tool to a 16 by 19-foot tool. This didn't appear to be a particularly important problem until cost estimates of the larger tool were completed and compared to original contract estimates. This newly designed tool would cost approximately 30 percent more than the original tool and would almost double the fabrication flow time. Since the contract could not accommodate either the increase in cost or flow time, the Vacu-form tool was redesigned to a smaller size with a slight compromise of original specification.

The redesigned Vacu-form tool is shown in Figure 1. It represents a reduction of heating zones (20 to 16); a reduction in fire brick, foam blocks, and glasrock cement (50 percent); and reduction of steel structure (20 percent) over the large tool designed in Phase I. The compromise made to suit the smaller size was to require that the clamp bar assembly (see Figure 1) be curved and that the forming diaphragm be severely deformed in some areas to accommodate sharp die surface transitions. However, we do not believe this will jeopardize the program.

OVERALL PROGRAM

Design of Gore Segment

The design of the gore segment is not yet complete. The design is being made to optimize the weight savings that can be accomplished with the use of 1/2-inch

titanium plate material. The design is expected to be completed by December 10, 1965.

Tool Fabrication

Tool designs are available for both the Screed tool and the Vacu-form tool. The Screed tool is used to make the forming tool. See Figure 1 for a cut-away of the forming tool.

The general sequence for fabricating the Vacu-form tool is as follows:

1. The concrete base was cast on the factory floor. It contained sufficient steel for reinforcement and for attachement to the steel box.
2. The steel box was welded together and was also attached to the cement base by welding.
3. Each of the welded joints of the steel box were sealed with "Grossmanite" to prevent vacuum leakage.

After the steel box was attached to the cement slab and the Screed tool was in place, construction was started on the internal structure of the steel box. See Figures 2 and 3. The fabrication sequence of the internal structure of the steel box was as follows:

1. Conventional fire brick was cemented in place to within 6 inches of the final contour. The general contour was maintained by checking with the Screed tool. A piece of rubber 6 inches wide was attached to the Screed blade and the height of the fire brick buildup was established by swinging the Screed tool to any location for checking. See Figures 2 and 3.
2. The last layer of bricks were band sawed when required to obtain the general gore configuration. Approximately 4,000 fire bricks were used.
3. To provide a uniform base for the Glasrock foam blocks, the fire brick surface was covered with a castable cement and screeded to contour with the Screed tool. See Figure 4. A plywood screed blade which was 5-3/4 inches below final contour was used. This Screed tool did a good job. The minimum depth of the castable cement was 1/4 inch and the maximum depth

was 3 inches. The median depth was 1 inch.

4. The Glasrock blocks (50-pound density, 4-1/2 by 18 by 18 inches) were then cemented to the castable cement surface. See Figure 4. To check the deviation from contour because the flat blocks were cemented to a curved surface, a plywood screed blade was used that was 1-1/4 inch below final contour. The maximum distance from the screed blade to the Glasrock blocks was 0.75 inch, the minimum was 0.01 inch, and the median was 0.25 inch.

5. The last row of Glasrock blocks at each end of the die were cut to give a thickness of 3-3/4 inches. This was 3/4 inch below the nominal block surface. In this location, the wax* covered tubing for the extra edge heaters was placed and secured with Glasrock cement. The edge heater tubes were placed at this level so that the tubing that runs lengthwise of the die would pass over them.

6. A half-inch layer of Glasrock cement was screeded over the Glasrock blocks and the edge heater tubing. This surface had a maximum depth of 3/4 inch, a minimum depth of 3/8 inch, and a median of 1/2 inch.

7. Wax* covered tubes were located in the die at a spacing of 0.75 inch, centerline measurement. There are 14 zones across the die each having 10 tubes for a total of 140 tubes. These 140 tubes run the length of the die and are in lengths of 13 feet to 16 feet depending on their location. The tubes were located by plywood templates grooved on 0.75-inch centerlines. Weights were placed on the tubes and they were secured in place with Glasrock cement. After the cement had hardened, the weights and templates were removed.

8. The finish surface of the die was made by screeding a 3/8-inch coating of Glasrock cement over the top of the tubular heating elements. The maximum thickness of the top surface was 7/16-inch thick, the minimum was 5/16-inch thick, and the median was 3/8-inch thick.

To date the Vacu-form tool is approximately 85 percent complete. Work yet to be done includes the electrical hookup, closing in the ends of the die, electrical check, vacuum check, and contour and performance check. Expected completion date is about December 15, 1965.

*Sheets of wax (0.020 thick) are layed up on the tubes before the tubes are placed in the tool. This wax will burn out when the tool is "fired" leaving space for tube expansion.

Screed Tool, Drawing EMIT 12R17260

The function of the Screed tool is to provide a means of controlling the contour of the Vacu-form tool at the various levels of construction. See Figure 5. The proper thickness of each layer of material is maintained with the use of the Screed tool. Governing the thickness of the different layers of materials is important in providing a uniform heat distribution in the die surface. The Screed tool also provides a means of inspecting the final contour of the die and gore segment. The critical features of the Screed tool in the inspection function is the template contour and its relationship to the sweep of the Screed arm.

The construction steps of the Screed tool are as follows:

1. A 16-inch diameter steel pipe, 9 feet long was welded to a steel base plate 1 by 48 by 48 inches. This is the stanchion assembly.
2. The bearing-holding structure was then mounted on the top plate of the stanchion assembly and temporarily bolted in place.
3. The Screed arm assembly consists of a steel pipe 10 inches in diameter and 19 feet long which has a provision at its midpoint for attaching to the bearing-holding-structure. To the lower end of the Screed arm, the near end of the Screed blade is attached so as to provide a gore configuration contour to the surface of the Vacu-form tool when the arm is swept through its arc. The upper half of the Screed arm only provides a counterbalance. A 3-inch diameter steel tube is attached to the far end of the Screed blade and the Screed arm as a brace.

When the Screed tool was completed, it was placed in its correct relationship to the Vacu-form tool and welded to it. The Screed tool template and its relationship to the Screed tool sweep will be checked by Quality Control before the Vacu-form die contour is inspected.

Vacuum Chuck

A vacuum chuck is required to hold the titanium plate during the machining operation. A vacuum chuck approximately 4 feet by 7 feet is available, so we will fabricate another chuck the same size. This will give us a chuck 4 by 14 feet. Our machining equipment will not accommodate a chuck any larger than this. Therefore, the machining operation will be accomplished in two steps, one-half the part at a time. The vacuum chuck will be completed by December 15, 1965.

Trim Fixture

A trim fixture is being designed and will be completed by December 15, 1965. Our original plan was to use a skate attachment for the final trim of the part. However, a quicker and more economical method involving friction sawing with a skill saw is to be used. This sawing operation will be followed by belt sanding to finish the edge.

Manufacturing Plan

The manufacturing plan is being written and is expected to be completed by December 15, 1965.

Conclusions

The progress to date in Phase II has been excellent and barring unexpected difficulties, Phase II of the contract should be completed by January 1, 1966.

VACUUM FORM DIE FOR TITANIUM GORE

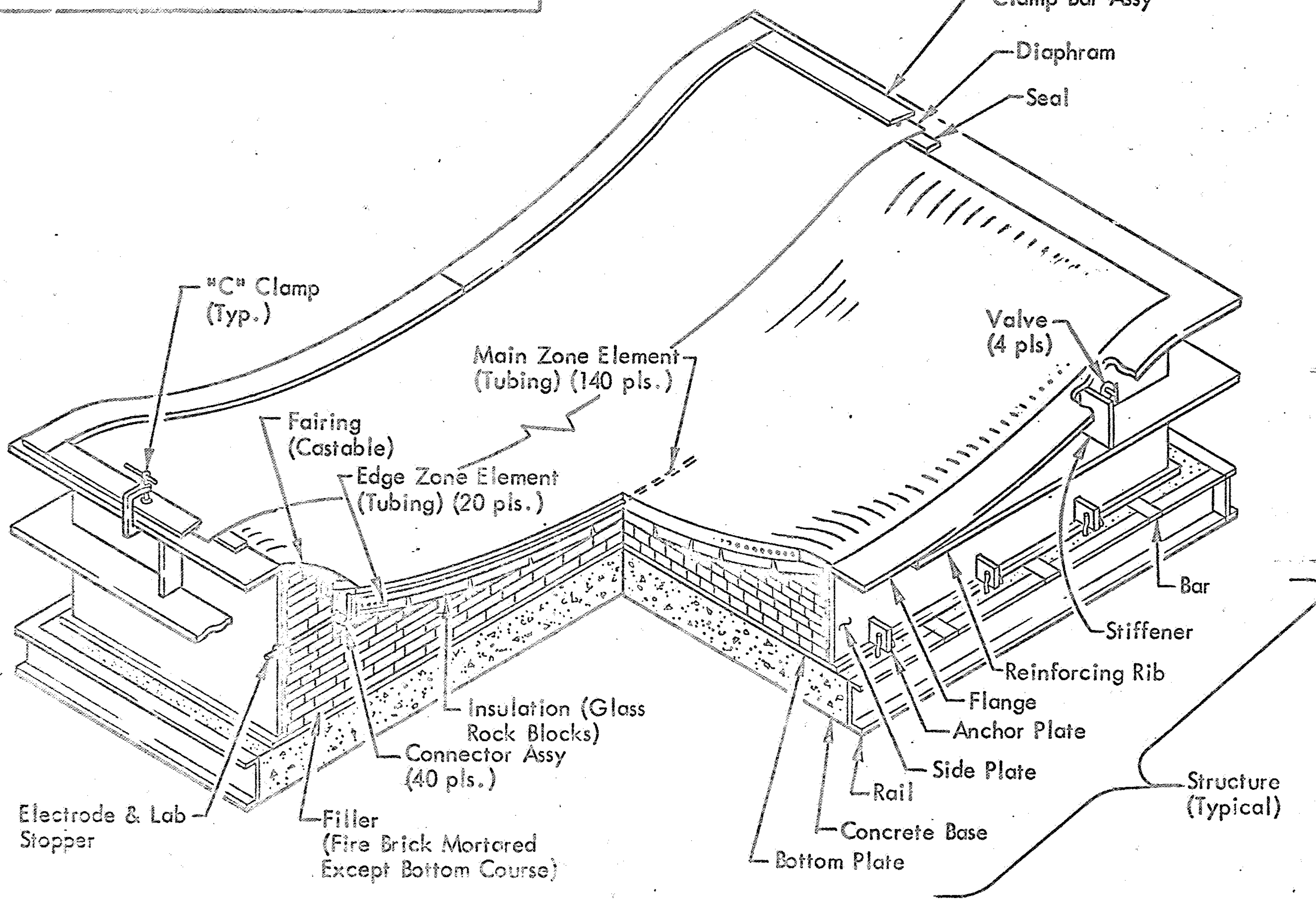

FIGURE 1

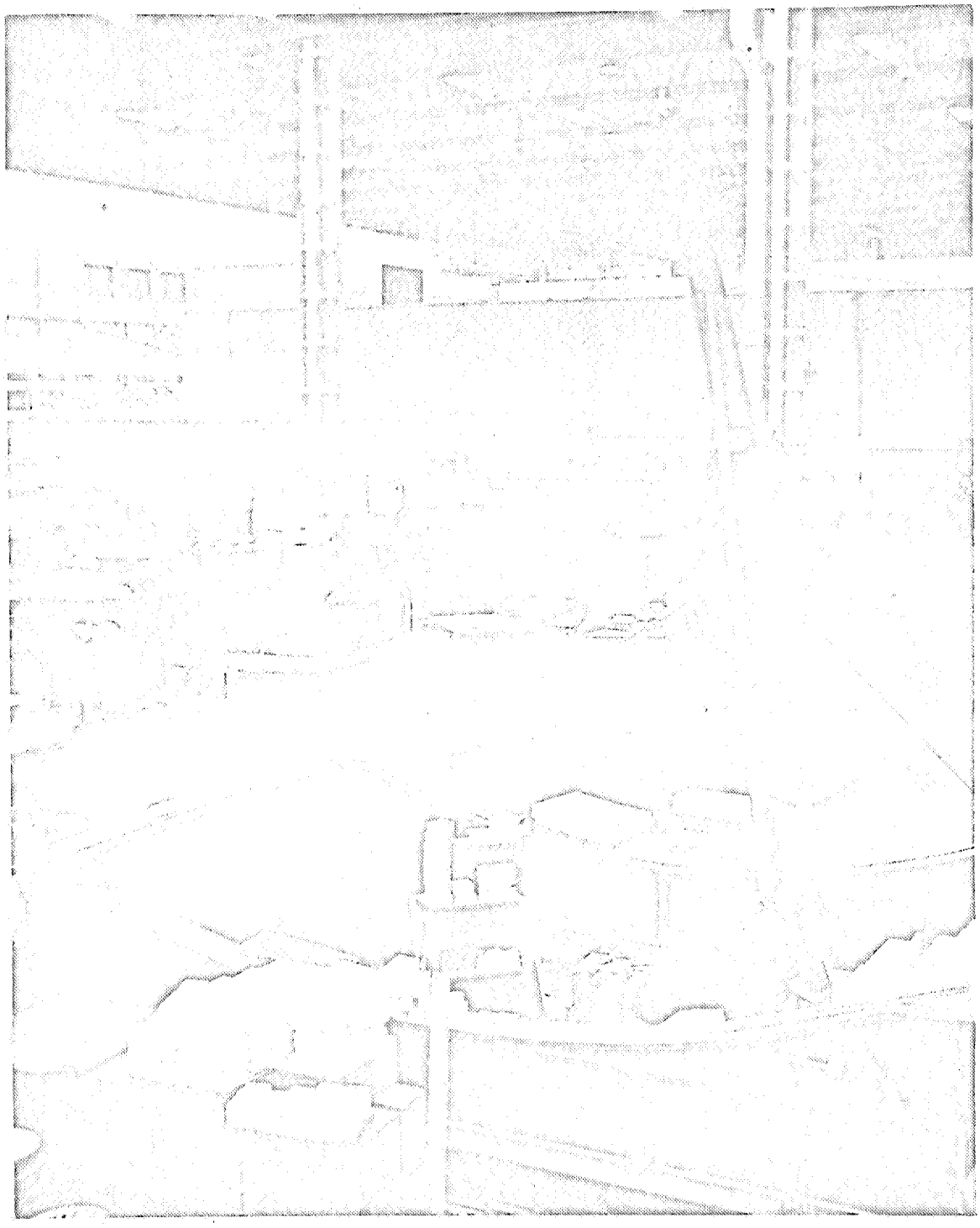

FIGURE 2

INTERNAL CONSTRUCTION OF THE VACU-FORM TOOL SHOWING FIRE-BRICK BEING LAID. THE SCREED TOOL IS BEING USED TO CONTROL FIRE-BRICK PLACEMENT.

FIGURE 3

VACU-FORM TOOL CONSTRUCTION

FIGURE 4

VACU-FORM TOOL CONSTRUCTION SHOWING GLASROCK FOAM BLOCKS BEING CEMENTED IN PLACE AND CHECKED BY THE SCREED TOOL FOR CONTOUR.

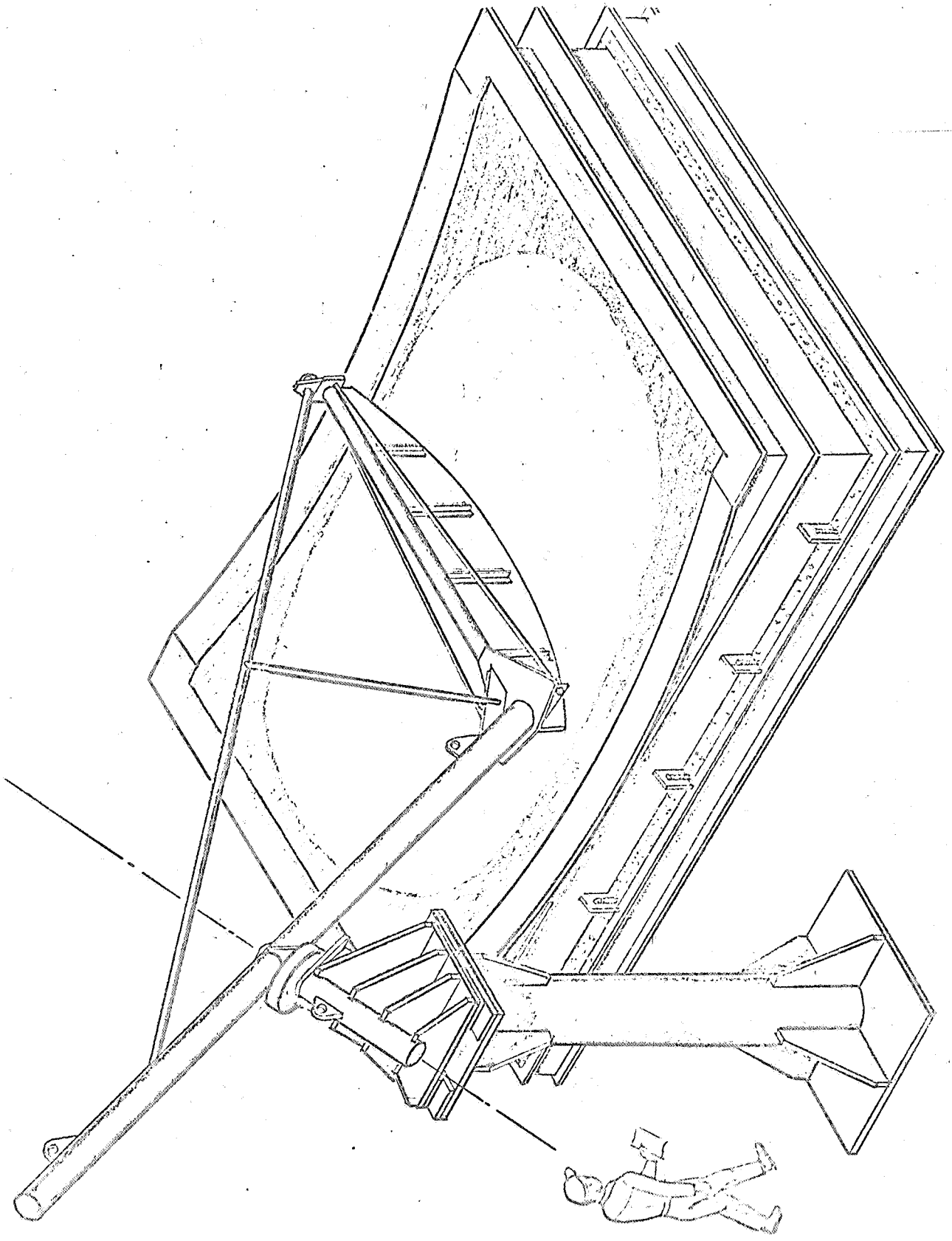

FIGURE 5

SCREED TOOL AND ITS RELATIONSHIP TO THE VACU-FORM TOOL

RESEARCH & DEVELOPMENT FOR FABRICATING A SIMULATED TITANIUM ALLOY BASE GORE SEGMENT, LOWER BULKHEAD, FOR THE S-1C FUEL TANK

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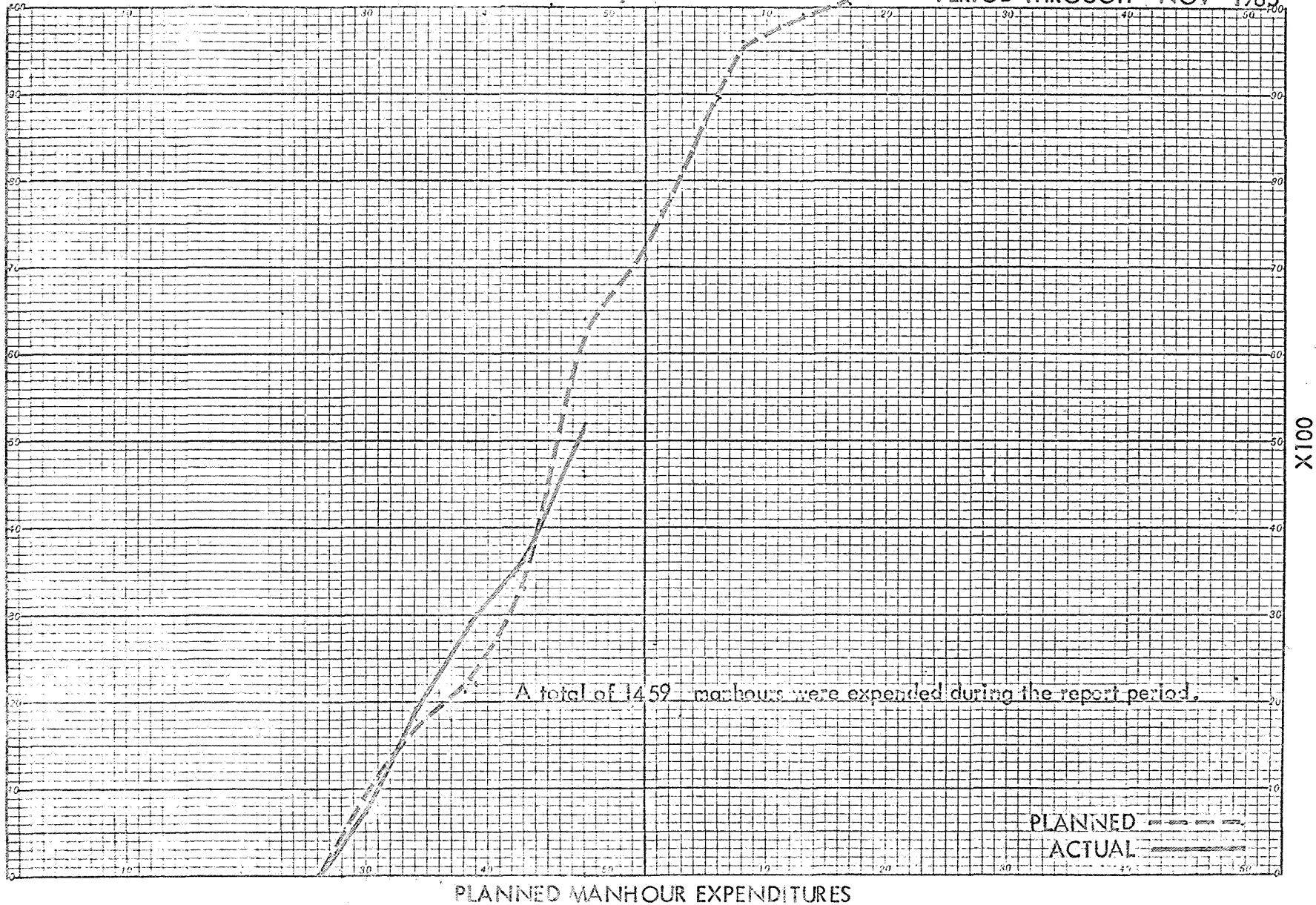
PERIOD THROUGH 30 NOV 1965



PLANNED MANHOUR EXPENDITURES

1965	1966